

## New Distributional Records for the Mycoheterotrophic Orchid

### *Kalimantanorchis nagamasui* from Sabah, Borneo, Malaysia

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Several new populations of the mycoheterotrophic orchid *Kalimantanorchis nagamasui* from Sabah, Borneo, Malaysia, are reported. The species was previously considered endemic to West Kalimantan, Borneo, Indonesia. Given that the continued discovery of new species and distributional records of mycoheterotrophic plants have been made from only a limited number of surveys in a small selection of sites, it is likely that further surveys in Borneo will reveal additional occurrences. The description of the morphology, in particular on the underground parts and size variation, of *K. nagamasui* is also updated.

Key words: Borneo, description, mycoheterotroph, Maliau Basin, Orchidaceae, Sabah

The most prominent sections of rainforest habitat within the Sundaland biogeographical region are located in Borneo, Java, Sumatra, and Peninsular Malaysia (Merckx *et al.* 2013). Approximately 60% of the 25,000 plant species in Sundaland are endemic. It is therefore alarming to note that the high rate of habitat destruction has resulted in it becoming one of the most threatened rainforest environments in the world (Myers *et al.* 2000). The region supports some of the most species-rich plant communities on Earth and is consequently also a hot spot for mycoheterotrophic plants. Given that mycoheterotrophic plants are highly dependent on both the fungi and the trees that sustain them (e.g. Suetsugu *et al.* 2014), they are particularly sensitive to environmental destruction. It has therefore been suggested that species richness of these specialized plants provides a useful indicator of the overall floral diver-

sity of forest habitats (Merckx *et al.* 2013). Detailed records of the distribution of these vulnerable plants thus provide crucial data for conserving tropical forests (Tsukaya *et al.* 2014b).

Borneo has by far the highest diversity of fully mycoheterotrophic plants among the three major islands (Borneo, Java, and Sumatra) within the Sundaland region (e.g. Tsukaya & Okada 2005, 2012a, 2012b, 2013a, 2013b, Tsukaya & Suetsugu 2014, Tsukaya *et al.* 2011, 2014a, 2014b). The approximately 65 species of mycoheterotrophic are more than the number documented for the whole of tropical Africa (Merckx *et al.* 2013). The high rate of endemism in Borneo is particularly pronounced in Thismiaceae and Orchidaceae. Ten species of *Thismia* and at least 17 species of orchids (*Aphyllorchis kemulensis* J.J. Sm., *A. siantanensis* J.J. Sm., *A. spiculaea* Rchb.f, *Cystorchis saprophytica* J.J. Sm., *Didymoplexis lati-*

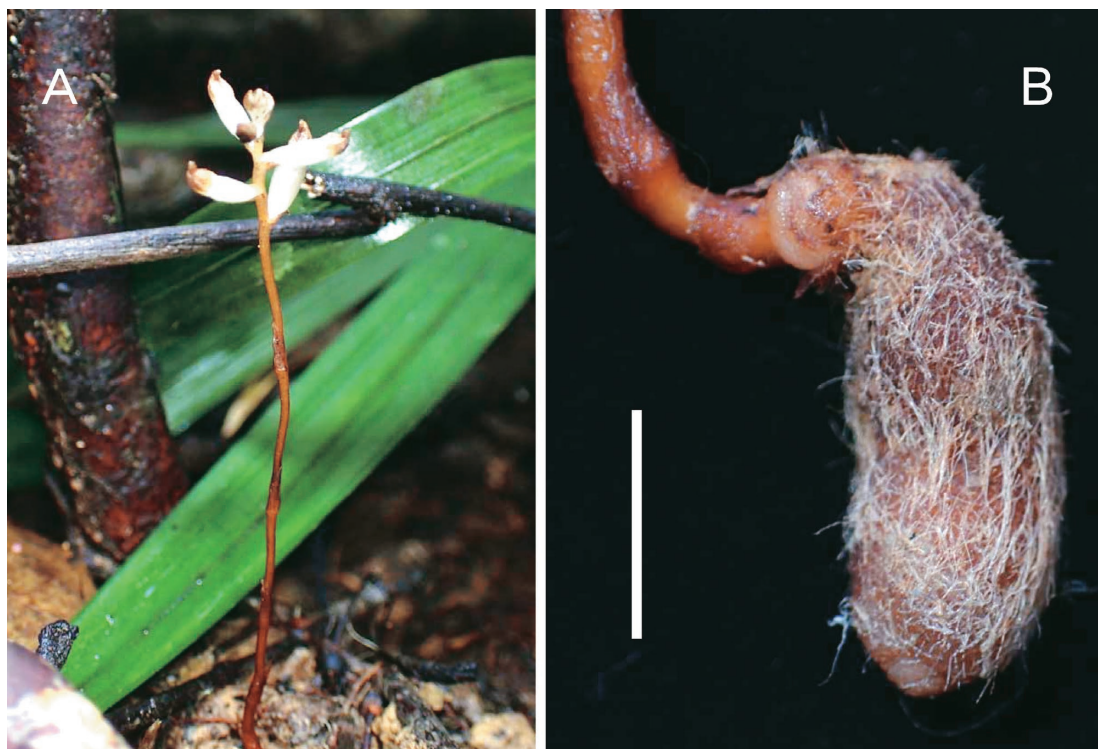


FIG. 1. A. Fruiting plant of the mycoheterotrophic orchid *Kalimantanorchis nagamasui* in the Maliau Basin Conservation Area, Borneo, Malaysia. B. Underground part of *K. nagamasui* in the Maliau Basin Conservation Area, Borneo, Malaysia.

*labris* Schltr., *Didymoplexiella borneensis* (Schltr.) Garay, *D. cinnabarina* Tsukaya, M. Nakaj. & H. Okada, *D. forcipata* (J.J. Sm.) Garay, *D. kinabal-*

*uensis* (Carr) Seidenf., *Kalimantanorchis nagamasui* Tsukaya, M. Nakaj. & H. Okada, *Gastrodia grandilabris* Carr, *G. sabahensis* J.J. Wood & A.L. Lamb, *G. spathulata* (Carr) J.J. Wood, *Platanthera saprophytica* J.J. Sm., *Lecanorchis betung-kerihunensis* Tsukaya & H. Okada, *Tropidia saprophytica* J.J. Sm., and *T. connata* J.J. Wood & A.L. Lamb) are endemic to Borneo (Tsukaya & Okada 2012a, Merckx *et al.* 2013, Tsukaya & Okada 2013a, Dančák *et al.* 2013, Hroneš *et al.* 2015). *Kalimantanorchis nagamasui* is particularly intriguing, as it constitutes a monotypic genus (Tsukaya *et al.* 2011).

*Kalimantanorchis nagamasui* closely resembles mycoheterotrophic members of *Tropidia* in both its mycoheterotrophic life history and its flower and stem morphology, including a branching stem, nonresupinate flowers with a saccate lip bearing two longitudinal ridges along the margins; a broadly triangular rostellum; an acute, triangular anther cap; and a winged or three-lobed column (Chan *et al.* 1994, Wood & Lamb 1994,

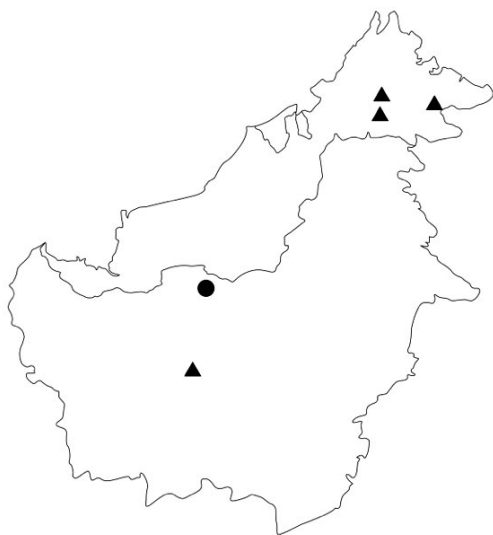


FIG. 2. Map showing occurrence of *Kalimantanorchis nagamasui*. Circle: Type locality. Triangles: New localities reported in this study.

Tsukaya *et al.* 2011). However, *Kalimantanorchis nagamasui* differs significantly in having small ivory-white flowers with four pollinia (Chan *et al.* 1994, Wood & Lamb 1994, Tsukaya *et al.* 2011). Unfortunately, the limited information available on the morphology of the underground parts of *Tropidia* hampers comparison of *K. nagamasui* with *Tropidia*. The similarity between the two groups has been confirmed by BLAST analyses using DNA sequences of chloroplast *matK* pseudogenes and ITS nuclear ribosomal DNA, suggesting the closest relationship between *K. nagamasui* and *Tropidia* (Tsukaya *et al.* 2011). However, a molecular phylogenetic analysis indicated that *K. nagamasui* was not a member of *Tropidia*, confirming that *Kalimantanorchis* is a unique genus (Tsukaya *et al.* 2011).

Although *Kalimantanorchis nagamasui* was previously considered to be endemic to the Betung Kerihun National Park in the West Kalimantan region of Borneo, Tsukaya (2013) found an unannotated herbarium specimen [J. K. Jarvie and A. Ruskandi, January 26, 1995 (BO-0126352)] from Samba, Central Kalimantan, Borneo, Indonesia. It is therefore likely that additional surveys could reveal more precise data regarding the diversity and distribution. As anticipated, during our recent field and herbarium studies, we found several new populations of *K. nagamasui*, which represent the first known occurrence from Sabah, Borneo, Malaysia.

Because *Kalimantanorchis nagamasui* was originally described based on only one individual, we here update the description of *K. nagamasui* using specimens discovered after the original description was prepared. In particular, size variation and the morphology of the underground part is updated.

***Kalimantanorchis nagamasui* Tsukaya, M. Nakaj. & H. Okada in Syst. Bot. 36: 52 (2011) — Fig. 1.**

*Specimens examined.* MALAYSIA. Sabah: Maliau Basin Conservation Area, from Nepenthes Camp to Agathis Camp, 04°42'06"N, 116°53'47"E, 30 September,

2016. H. Tsukaya, K. Suetsugu & M. Suleiman TSS-30 (BORH, specimen preserved in 50% ethanol); Pinangah district, Imbak River Camp 1,200 m alt., 7 July 2000. *De Wilde, Tajudin & Good SAN 143937* (SAN); Lahad Datu District, Gunung Silam, 4°58'N, 118°10'E, 200–300 m alt., 10 June 1984. *J. H. Beaman K000480278* (K).

INDONESIA. West Kalimantan: Kabupaten Kapuas Hulu, Putussibau, Betung Kerihun National Park, Sungai (River) Menyakan, upstream of Sg. Siba, 01°13'29.8"N, 113°04'21.5"E, 191 m alt. — 01°13'41.8"N, 113°04'13.9"E, 210 m alt. along ridge, 5 January 2011, H. Tsukaya H. Okada & H. Nagamasu 1035 (BO, TI); Kabupaten Kapuas Hulu, Putussibau, Betung Kerihun National Park, a branch upstream from base camp beside Sg. Minyak, a branch of Sg. Sibau, 28 December 2011, H. Tsukaya, H. Okada, & A. Soejima 229 (BO, TI); Kabupaten Kapuas Hulu, Putussibau, Betung Kerihun National Park, near to Sg. Nuo, a branch of Sg. Minyak, a branch of Sg. Sibau, H. Tsukaya, H. Okada & A. Soejima 258 (BO, TI). Central Kalimantan: Samba, 1994–1995 cutting blocks of P.T. Handiyani, 00°43'16.7"S, 112°50'34.2"E, 26 January 1995. *J. K. Jarvie & A. Ruskandi s.n.* (BO-0126352).

Herbs, terrestrial, mycoheterotrophic. Stems erect, rigid, branched or unbranched, with sheaths at nodes, 6–13 cm tall, 0.8 mm in diameter, lateral or at apex of tuber. Tubers 0.8–3 cm long, 0.5–0.9 cm in diameter. Sheath thin, pale brown, less than 4 mm long, linear-lanceolate, acute. Inflorescence a raceme, with scattered dark brown hairs, bearing 5–15 flowers. Bracts ovate, acute to acuminate, brown, 1.5–2.5 mm long, with dark brown hairs on abaxial surface; ovary cylindrical, 2 mm long. Flowers ivory-white, nonresupinate, 3 mm wide; sepals free, oblong, with scattered hairs on abaxial surface; dorsal sepal 2.6–2.7 × 1.2–1.3 mm; lateral sepals oval, 2 × 1.2–1.3 mm, abaxial surface hairy; petals free, oblong, 2.3 × 1.3 mm, margin erose; lip loosely embracing column at base, distally expanded, apex acuminate, recurved, without spur, with two longitudinal ridges along margins, 1.7 × 1.4 mm; column laterally winged or 3-lobed, 0.9 mm long; clinandrium triangular; anther dorsal, triangular, 1 × 0.7 mm, apex acute, tip transparent, erect; rostellum broadly triangular, erect; pollinia 4. Capsules ivory-white, with persistent brown perianth tube, obovoid-oblong or ellipsoid, 6–7 × 2 mm.

*Notes.* We found only one fruiting individual of *Kalimantanorchis nagamasui* in the Maliau Basin Conservation Area, which, based on the

shape and size of the dense inflorescence and fruit, we were able to identify. In addition, the persistent perianth tube in fruit confirmed that our collection was identical to *Kalimantanorchis nagamasui*. The habitat was the wet understory of a kerangas forest dominated by the species of Dipterocarpaceae and *Agathis*.

We also found two specimens of *Kalimantanorchis nagamasui* during herbarium studies, which indicate that other populations occur in Sabah, Borneo, Malaysia. Although the specimens were annotated as *Tropidia saprophytica* (by J.J. Wood) and *T. connata* (by A.L. Lamb), we could distinguish the specimens from these two myco-heterotrophic *Tropidia* based on floral features; e.g., the flowers of *T. saprophytica* and *T. connata* are much larger than *K. nagamasui*.

*Kalimantanorchis nagamasui* also occurs in Kinabalu Park, Sabah, Malaysia, based on the photograph at <http://www.pbse.com/rogiervanvugt/image/142283405>. Further investigation is needed to determine the precise distribution of this unique species.

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## References

- Chan, C. L., A. Lam, P. S. Shim & J. J. Wood. 1994. Orchids of Borneo, vol.1. The Sabah Society, Kota Kinabalu and The Royal Botanic Gardens, Kew.
- Dančák, M., M. Hroneš, M. Sochor, L. Kobrlova, R. Hédli, Z. Hrázský & F. Metali. 2013. A new species of *Thismia* (Thismiaceae) from Brunei Darussalam, Borneo. *Phytotaxa* 125: 33–39.
- Hroneš, M., L. Kobrlová, V. Taraška, O. Popelka, R. Hédli, R. S. Sukri & M. Dančák. 2015. *Thismia brunneomitra*, another new species of *Thismia* (Thismiaceae) from Ulu Temburong, Brunei Darussalam. *Phytotaxa* 234: 172–178.
- Merckx, V. S. F. T., J. V. Freudenstein, J. Kissling, M. J. M. Christenhusz, R. E. Stotler, B. Crandall-Stotler, N. Wickett, P. J. Rudall, H. Maas-van de Kamer & P. J. M. Maas. 2013. Taxonomy and classification. In: Merckx, V. S. F. T. (ed.), *Mycoheterotrophy: The Biology of Plants Living on Fungi*, pp. 19–101. Springer Science+ Business Media, New York.
- Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. D. Fonseca & J. Kent. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403: 853–858.
- Suetsugu, K., A. Kawakita & M. Kato. 2014. Evidence for specificity to *Glomus* group Ab in two Asian myco-heterotrophic *Burmanniea* species. *Pl. Spec. Biol.* 29: 57–64.
- Tsukaya, H. 2013. Nomenclature Notes: *Kalimantanorchis*. *Orchids* 82: 310–311.
- Tsukaya, H. & H. Okada. 2005. *Thismia mullerensis* (Burmannieaceae), a new species from Muller Range, Central Kalimantan. *Acta Phytotax. Geobot.* 56: 129–133.
- Tsukaya, H. & H. Okada. 2012a. A new species of *Thismia* (Thismiaceae) from West Kalimantan, Borneo. *Syst. Bot.* 37: 1–5.
- Tsukaya, H. & H. Okada. 2012b. A new variety of *Didymoplexis cornuta* (Orchidaceae) from West Kalimantan, Borneo. *Acta Phytotax. Geobot.* 62: 89–93.
- Tsukaya, H. & H. Okada. 2013a. A new species of *Lecanorchis* Blume (subfamily Vanilloideae, Orchidaceae) from Kalimantan, Borneo. *Syst. Bot.* 38: 69–74.
- Tsukaya, H. & H. Okada. 2013b. Two new species of *Sciaphila* Blume (Triuridaceae) from Kalimantan, Borneo, with a new record of *S. thaidanica* from Borneo. *Syst. Bot.* 38: 600–605.
- Tsukaya, H., M. Nakajima & H. Okada. 2011. *Kalimantanorchis*: a new genus of mycotrophic orchid from West Kalimantan, Borneo. *Syst. Bot.* 36: 49–52.
- Tsukaya, H. & K. Suetsugu. 2014. Two new species of *Sciaphila* (Triuridaceae) from Sarawak (Borneo, Malaysia). *Phytotaxa* 170: 283–290.
- Tsukaya, H., M. Suleiman & H. Okada. 2014a. Discovery

- of *Didymoplexiella trichechus* (J. J. Sm.) Garay and a new variety of *Didymoplexis cornuta* J. J. Sm. (Orchidaceae) from Borneo. *Acta Phytotax. Geobot.* 65: 105–110.
- Tsukaya, H., M. Suleiman & H. Okada. 2014b. A new variety of *Thismia hexagona* Dančák, Hroneš, Koblrová et Sochor (Thismiaceae) from Sabah, Borneo, Malaysia. *Acta Phytotax. Geobot.* 65: 141–145.
- Wood, J. J. & A. Lamb. 1994. *Tropidia connata*. In: Wood, J. J. & P. J. Cribb. (eds.), A checklist of orchids of Borneo, pp. 47–49. Royal Botanic Gardens, Kew, London.

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